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Factors influencing the female sex attractiveness in pine sawflies
Diprion pini and *Neodiprion sertifer* (Hym. Diprionidae)¹

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The attractiveness of individual virgin females of pine sawflies is extremely variable. Some factors which influence the female attractiveness, namely, previous mating, host factors, age of females, weather conditions and proximity of other females are discussed.

The existence of a sex attractant in virgin female sawflies was first reported by BENJAMIN (1955) for *Neodiprion lecontei* FITCH. A similar pheromone was shown by COPPEL *et al.* (1960) for *Diprion similis* HARTIG. These initial results led to further tests with species such as *D. similis* (CASIDA *et al.*, 1963), *N. sertifer* GEOFFROY (BOBB, 1964), *N. fulviceps* CRESSON, *N. abietis* HARRIS and *N. virginianus* (see MERTINS, 1971, for review).

JEWETT *et al.* (1976) identified a free alcohol, 3,7-dimethylpentadecan-2-ol, in three species from two different sawfly genera. In *N. lecontei* and *N. sertifer*, the acetate of this alcohol was the major component of their attractant; *D. similis* it was the propionate. By examining the responses of several other species by means of electroantennograms (EAGs), it was found that four species responded primarily to the acetate and six species to the propionate. In field tests, the synthetic acetate attracted males of *N. sertifer*, *N. lecontei* and *D. frutetorum*; the synthetic propionate attracted males of *D. similis* and *N. swaini* MIDDLETON.

Table 1: Male response to sticky traps baited with *D. pini* virgin females (one female per trap)

Stedden 1977	t r a p s					
	A	B	C	D	E	F
May 7	558	1	1	117	*	*
" 8	298	3	5	10	*	*
" 9	476	2	7	0	77	*
" 10	0	1	53	0	211	16
" 11	0	3	49	1	522	20
total males attracted	1332	10	115	128	810	36

* = not baited

¹Paper presented at the Conference on «Dispersal of forest insects: evaluation, theory, and management implications», sponsored by the Intern. Union of Forest Research Organization (IUFRO), Entomology Dept. of the Swiss Federal Institute of Technology, Zürich and Zuoz, Switzerland, 4-9 September, 1978.

We conducted field trials with two important European species: *D. pini* and *N. sertifer*. The existence of an attractant in the female of *D. pini*, the most injurious pine sawfly in Europe (and one which does not occur in the USA), had not yet been studied. Only males were attracted to traps baited with virgin females. However, the attractiveness of individual virgin females was extremely variable. Some females attracted several hundred males during one day, while others lured none or only a few (table 1). Differences in attractiveness of individual females has also been observed in the USA (COPPEL *et al.*, 1960; BOBB, 1972). We found several factors such as previous mating, host factors, age of females, weather, proximity of other females, to influence the attractiveness of traps baited with females.

In the following experiments sticky traps containing caged female sawflies were used.

Table 2: *Diprion pini*: male response to virgin and mated females

Dudenhofen 1978	virgin females		mated females	control
	A	B		
July 22	109	40	0	0
" 23	29	1	0	0
total males attracted	179		0	0

Influence of mating

In agreement with data obtained from American species (CASIDA *et al.*, 1963), mated females are not attractive (tables 2 and 3). The loss of attractiveness after a mating is perhaps advantageous as the females may then oviposit without male interference. Virgin females deposit eggs which develop parthenogenetically. With the beginning of parthenogenetic oviposition virgin females are no longer attractive. However, if egg laying is interrupted, attraction may reoccur.

Table 3: *Neodiprion sertifer*: male response to virgin and mated females

Hartheim/Grissheim 1976	virgin females	mated females	control
total males attracted (4 traps each)	254	10	0

Host factors

Host factors also influence female attractiveness. The attractiveness of virgin females is greater if contact with the host plant is provided. To study this influence, small pine twigs were added to the cage of the female; the control trap also contained a pine twig (tables 4 and 5). Contact with the host plant pine twigs prolonged the life of virgin females and appeared to enhance their attraction

Table 4: *Diprion pini*: male response to traps

Reilingen 1977	virgin females with pine			b a i t e d w i t h	control with pine only
	A	B	C	virgin females without pine	
April 22	290	8	302	3	0
" 24	216	213	297	1	0
per trap/day	221			2	0

relative to virgin females in traps without pine twigs. Since sawflies do not feed as adults, the apparent increase elicited by the addition of pine twigs to traps baited with virgin females might be attributed to chemical or tactile stimuli from the pine needles. This question is under investigation.

Table 5: *Neodiprion sertifer*: male response per trap per day (range)

Hartheim/Grissheim 1976	virgin females with pine		b a i t e d w i t h	control with pine only
			virgin females without pine	
Oct. 3 and 4	26,4 (0- 96)		7,8 (0- 34)	0
" 5 " 6	33,7 (9- 51)		8,8 (0- 66)	0
" 7 to 10	79,2 (0-261)		38,7 (0-116)	0,2 (0-1)

Age of females

Generally females are attractive immediately upon emergence from the cocoon (COPPEL *et al.*, 1960; CASIDA *et al.*, 1963; BOBB, 1964; JONES *et al.*, 1965). However, many females reach their maximal attractiveness only after a few days.

Table 6: *Diprion pini*: male response to virgin females of different ages

Reilingen 1977	Age of virgin females (in days)									
	1	2	3	4	5	6	11	16	18	20
female A	117	10	-	-	-	-	-	-	-	-
" B	-	-	-	-	-	-	-	290	216	-
" C	279	246	498	3	24	-	-	-	-	-
" D	-	-	-	-	-	-	-	-	-	-

Table 7: *Neodiprion sertifer*: male response to virgin females of different ages

Hartheim/Grissheim 1976	Age of virgin females (in days)									
	1	2	3	4	5	6	7	8	9	
female E	5	34	7	6	(t)					
" F	-	96	48	9	34	-	-	-	-	-
" G	-	-	-	5	33	-	25	(t)		
" H	-	-	5	7	4	12	66	51	38	

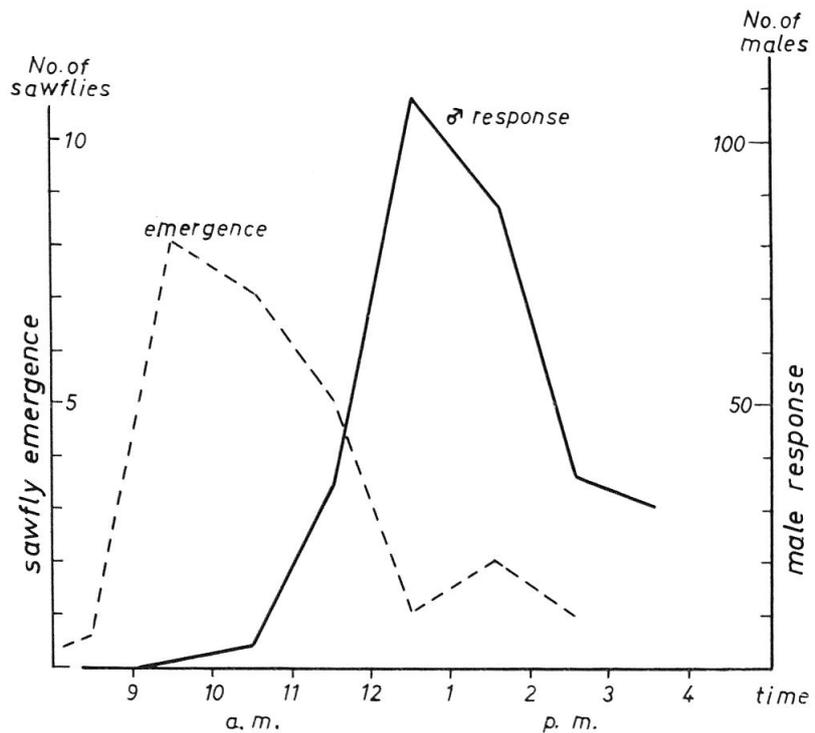
t = dead

Tables 6 and 7 show the change in attractiveness of females over several days. Only three were attractive on the first day; results were highly variable. Unmated female sawflies in some cases were still attractive after 2 weeks. Therefore, age had no definitive effect on virgin female attractiveness.

Weather

Ambient air temperature and light conditions (sunshine or cloud cover) influenced both female attractiveness and male flight activity. Male response of both *D. pini* and *N. sertifer* to the sticky traps peaked around noon, although *D. pini* catches occurred from 10 a.m. to 4 p.m. On cloudy days male response may be only from 10 a.m. to 1 p.m.

Fig. 1: Emergence and male response of *Diprion pini* to traps baited with virgin females



Frequency of response to the traps depends on the male emergence period. The sawflies emerge from their cocoons mainly between 8 and 11 a.m. On cool cloudy days only a few sawflies emerge and the trap catch is low, while on bright days when the rate of sawfly emergence is higher trap catch also increases. Sawfly emergence precedes peak trap catch by only 2-3 hours (fig. 1). It appears that female attractiveness coincides with the peak of male activity (10 a.m. to 4 p.m.).

Proximity of other females

Although increasing the number of virgin females in a trap might be expected to increase male response, field tests showed the opposite to occur (tables 8 and 9). The cages were subdivided to prevent mechanical contact of females in the same trap. The apparent decrease in female attractiveness may be

Table 8: *Diprion pini*: male response to virgin females

Dudenhofen 1978	number of females per trap			
	1 female	2 females	3 females	4 females
July 14 (1 trap)	34	5	4	1
" 22 (2 traps)	149	27	33	8
" 23 (2 traps)	30	24	10	7
" 29 (1 trap)	10	10	5	0
total males attracted	223	66	52	16

explained if one assumes attraction over large distances to be unnecessary at high population densities. It is possible that the loss of female attractiveness ultimately results in a lower egg deposition since fertilization is less likely to occur. According to BOBB (1964), the cause of a rapid population decline of the Virginia-pine sawfly, *N. pratti pratti* DYAR, was attributed to the loss of sex attractiveness by the females.

Unmated female sawflies are not excluded from reproduction, as unfertilized eggs produce only males. The trapping out of males does not cause a decline of the next generation, but increases the sex ratio in favour of the males due to the deposition of unfertilized eggs. However, the population does decline in subsequent generations because the percentage of females in the population decreases.

Table 9: *Neodiprion sertifer*: male response to virgin females

Hartheim/Grissheim 1976	\bar{x} male response / day / trap (range)	
	1 female	2 females
October 5	26 (9- 51)	10 (5-19)
" 6	28 (9- 66)	11 (1-21)
" 7	57 (10-178)	24 (3-39)

Therefore, trapping out of males in large numbers over several generations may be successful. MERTINS *et al.* (1975) have estimated this by means of a theoretical population model with a hypothetical sawfly population of *D. similis*. They conclude that four generations of intensive male trapping would be sufficient to eliminate the sawfly from an isolated area. This method is worthy of testing in field experiments when the synthetic pheromone becomes available in sufficient quantity.

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